Claims

[c1] 1. An over-voltage crowbar for lightning surge and ESD protection comprising:
a Zener diode, providing an over-voltage threshold under an over-voltage condition;
a clamping transistor, having a drain coupled to an input voltage so as to clamp the input voltage when the input voltage is higher than the over-voltage threshold;
a mirror amplifier, responsive to the input voltage for generating an amplified voltage to drive the clamping transistor in response to the over-voltage condition, wherein the input voltage is coupled to an input of the mirror-amp through the Zener diode, and an output of the mirror-amp is connected to a gate of the clamping transistor;
two resistors connected from the ground to the input of the mirror amplifier and the gate of the clamping transistor respectively for turning off the mirror amplifier and the clamping transistor in a normal operation condition; and
a speed-up capacitor accelerating a response time of the mirror amplifier.

[c2] 2. The over-voltage crowbar in accordance with claim 1, wherein the mirror amplifier comprises:
an n-transistor, having a gate coupled to the input of the mirror amplifier and a source connected to the ground;
a first p-transistor, having a drain, a gate and a source; anda second p-transistor, having a drain coupled to the output of the mirror amplifier, a gate coupled to the drain and the gate of the first p-transistor, and a source coupled to the source of the first p-transistor to the input voltage to form an amplifier for providing the amplified voltage to drive the clamping transistor in response to the over-voltage condition.

[c3] 3. The over-voltage crowbar in accordance with claim 1, wherein the speed-up capacitor is connected from the gate of the second p-transistor to the ground.

[c4] 4. The over-voltage crowbar in accordance with claim 1, wherein the speed-up capacitor is connected between the source and the drain of the second p-transistor.

[c5] 5. An over-voltage crowbar for lightning surge and ESD protection comprising:

a plurality of transistors, connected in series to provide an over-voltage threshold under an over-voltage condition;

a clamping transistor having a drain coupled to an input voltage so as to clamp the input voltage when the input voltage is higher than the over-voltage threshold;

a mirror amplifier responsive to the input voltage for generating an amplified voltage to drive the clamping transistor in response to the over-voltage condition, wherein the input voltage is coupled to an input of the mirror amplifier through the transistors, and an output of the mirror amplifier is connected to a gate of the clamping transistor;

two resistors connected from the ground to the input of the mirror amplifier and the gate of the clamping transistor respectively for turning off the mirror amplifier and the clamping transistor under a normal operation condition; and

a speed-up capacitor accelerating a response time of the mirror amplifier.